Sensor-Enhanced Armor May Be Key to Better Vehicle Protection

Chris Williams



HEMTTs from the 101st Airborne Division carry combat-modified versions of M998 High Mobility Multipurpose Wheeled Vehicles back to Forward Operating Base Remagen, Iraq, from a desert location. Sensor-enhanced armor testing developed by TARDEC has been implemented for a HEMTT prototype. (U.S. Army photo by SPC Teddy Wade.)

a crucial role in protecting Soldiers from deadly attacks. Researchers at the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) have developed new technology that delivers accurate, real-time vehicle armor analysis. The technique uses sensors embedded in a vehicle's armor plates and has been in development since Soldiers in the field requested it in 2007.

Because damaged plates sound different than healthy plates, armor was inspected with a "tap test" in which Soldiers tapped the armor and listened to the sound it made to determine whether plates had sustained damage. The technique was an accurate form of nondestructive testing, but it also had drawbacks. "The ear is very sensitive, but the problem is that the technique is not repeatable from Soldier to Soldier," explained Dr. Thomas Meitzler, Team Leader for

TARDEC's Non-Destructive
Testing and Evaluation (NDTE)
Laboratory. "Some Soldiers lose
part of their hearing because of
exposure to all of the explosives
and blasts. What we did was
develop an automated version
of this testing that lets the
computer do the processing and
determination of whether it's a
healthy or damaged plate."

The technique was developed to evaluate body armor and used sensors attached to the armor,

which was then scanned with a handheld device attached to an oscilloscope. When TARDEC's Survivability Non-Destructive Evaluation (NDE) Team was tasked to update the technique for use on vehicles, many of the system's components were retained, although the sensors now transmit to a computer instead of a handheld wand. "The key component is the piezoelectric transducer, which both generates

Through experimentation, **TARDEC** researchers discovered the best locations and number of transducers to embed into a plate in the manufacturing process.

and receives voltages," Meitzler remarked. "We generate a shockwave through the plate, which picks up the reflections of that sound wave and converts it to an electrical voltage from which we can determine its spectrum and whether the plate is cracked."

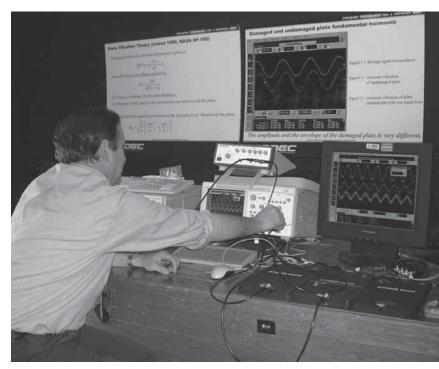
Through experimentation, TARDEC researchers discovered the best locations and number of transducers to embed into a plate in the manufacturing process. During testing, an ultrasonic signal is sent through the plate at 200 different frequencies, varying from one kilohertz (kHz) to 200 kHz. The test is repeated several times under various environmental conditions to collect data

that will comprise the plate's baseline, or "fingerprint." The fingerprint captures the plate's characteristics in an undamaged state. Data is stored on a chip so that the system recognizes an undamaged plate's signature. The plate can be tested again, and variations from that original signature reveal whether the plate is damaged and to what extent.

The sensors are developed specifically for the material that comprises the armor plates. Each sensor's shape is the same as the plate component itself for optimal readings. Ultrasonic testing is an ideal form of nondestructive testing and can be used on several armor materials and composites.

"Most of the armors we've been dealing with are based on some kind of silicon carbide or brittle ceramic, which makes the use of ultrasound appropriate," Meitzler continued. "But we have also seen success with some materials that you wouldn't think of using. For instance, pellet armor is a composite in itself. You wouldn't normally think you could use ultrasound for it. But it turns out that because of the way it's made, with the pellets touching each other, it transmits ultrasound very well."

The technique currently utilizes its own computer system, which will eventually be scaled down and integrated into warfighter displays on future vehicles. It uses a red-green-black color readout that easily identifies armor damage. The device will increase situational awareness by supplying Soldiers with real-time indicators when the vehicle is under attack, alerting



TARDEC NDTE Team Leader Dr. Thomas Meitzler studies the computer signature provided by sensors embedded in vehicle armor. This test capability studies armor fingerprints and uses comparisons to determine whether armor plates have sustained damage. (U.S. Army TARDEC photo by Chris Williams.)



TARDEC's Dr. Thomas Meitzler (left) and TARDEC Engineer Ivan Wong study the test results for a new armor component. (U.S. Army TARDEC photo by Chris Williams.)

them to any armor damage and assisting in determining whether to continue with a mission or return for repairs.

"For the Soldier, this gives them a greater understanding of what level of protection this armor is capable of giving, which impacts their survivability and helps them decide if they could do other missions, what kind of missions they could do or whether they should do something else," Meitzler explained. "It also provides more information for life cycle management, because if we have a tool to help decide if a plate is good or bad, we can cut down on the number of new plates needed because there is

now a computer system to help decide if it's still usable."

Sensor-enhanced armor has been implemented on one prototype for tactical wheeled vehicle systems on a Heavy Expanded Mobility Tactical Truck (HEMTT) as part of a field spinout. TARDEC is also in the process of implementing the technique as a prototype for Ground Vehicle Combat Development and two more demonstrators for tactical wheeled vehicle systems. More research is required before the device will attain a desired technology readiness level, but Meitzler believes the system shows promise. "So far, it looks very optimistic," he said. "We're

still doing a combination of test models to verify the scaling. We have to get some full-size panels from manufacturing and see what we have to do in terms of number of sensors. The physics will be the same, but the number of sensors may be different," Meitzler concluded.

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